Project #00-2

BUILDING INVESTMENT DECISION SUPPORT (BIDS)

Cost-Benefit Tool to Promote High Performance Components, Flexible Infrastructures, and Systems Integration for Sustainable Buildings and Productive Organizations

http://gaudi.arc.cmu.edu/bids

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1.0 Project Overview

1.1 Motivation

The goal of this project is to develop a cost-benefit analysis framework for various advanced and innovative building systems and to incorporate these within a multi-media decision support tool. The project has the following specific objectives:

1. The development of economic language and logic whereby intelligent workplace design can be thought of by the business investor as analogous to other emerging, strategically-central investments that have different operating life cycles (economic sustainability), competitive implications (workforce design), and payback periods (capital market valuation criteria).
2. The development of a cost-benefit analysis framework for evaluating various advanced and innovative building system options in relation to a range of cost-benefit or productivity studies, to be incorporated within a multimedia decision tool.
3. The determination of cost centers where the benefits of high performance approaches will be significant, and the expansion of a data base relating quality indoor environments to major capital cost and benefit areas, including productivity, health, and operations costs.
4. The identification of laboratory and field case studies demonstrating the relationship of high performance components, flexible infrastructures and systems integration to the range of cost-benefit or productivity indices.

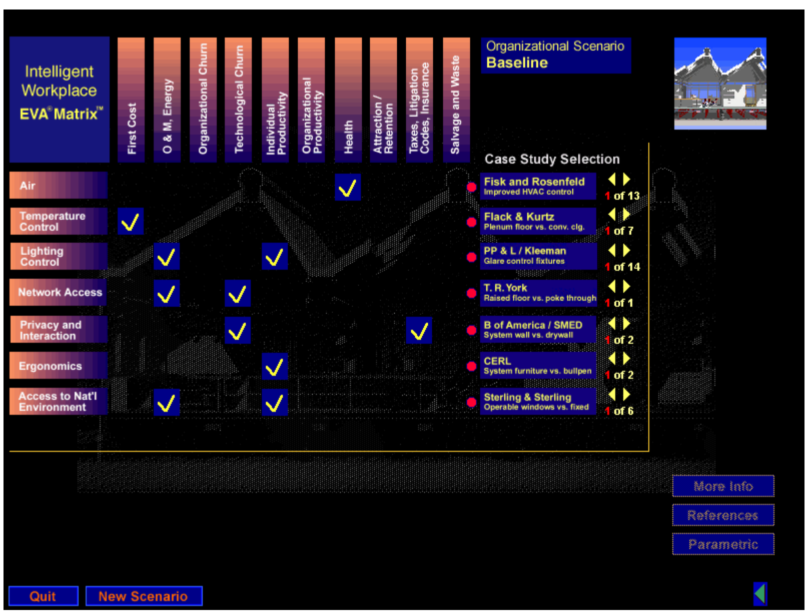


Figure 1. BIDS EVA® Matrix™

1.2 Importance of Research

The investment in higher performance building solutions and technologies is limited by first cost decision-making. The development of a life cycle tool comparing the cost-benefits of building technologies is central to the commercialization of higher performance building solutions. Several of the life cycle justifications fall directly into the DOE's mandate, including energy efficiency, waste management, indoor environmental quality, and renewability.

Energy efficiency is important from economic and environmental perspectives. Buildings consume a large portion of the primary energy in the U. S. every year. Typically in the U. S., the portion used by buildings represents 35%. The use of energy in buildings resulted in the release of 523 million metric tons of carbon in 1997. The impacts of indoor air quality in buildings has been estimated to be $60 billion annually in health costs and an 18% loss in productivity. A tool that demonstrates the cost-benefits of building technologies in these terms can help decision-makers choose the appropriate strategies that will improve the quality of workplaces in the U. S.

Investments in higher performance building solutions and technologies are limited by first cost decision-making. The development of a life-cycle tool identifying the cost-benefits of advanced building technologies is central to the commercialization of higher performance building solutions. The ten areas of life-cycle justifications include first cost, energy, operation and maintenance, individual productivity, organizational productivity, health, attraction/retention, organizational and technological renewal, tax/insurance and salvage.

1.3 Approach

Figure 2 shows the elements in the three dimensions of the matrix - design options, cost-benefit factors, and scenarios, which are explained in further detail below.

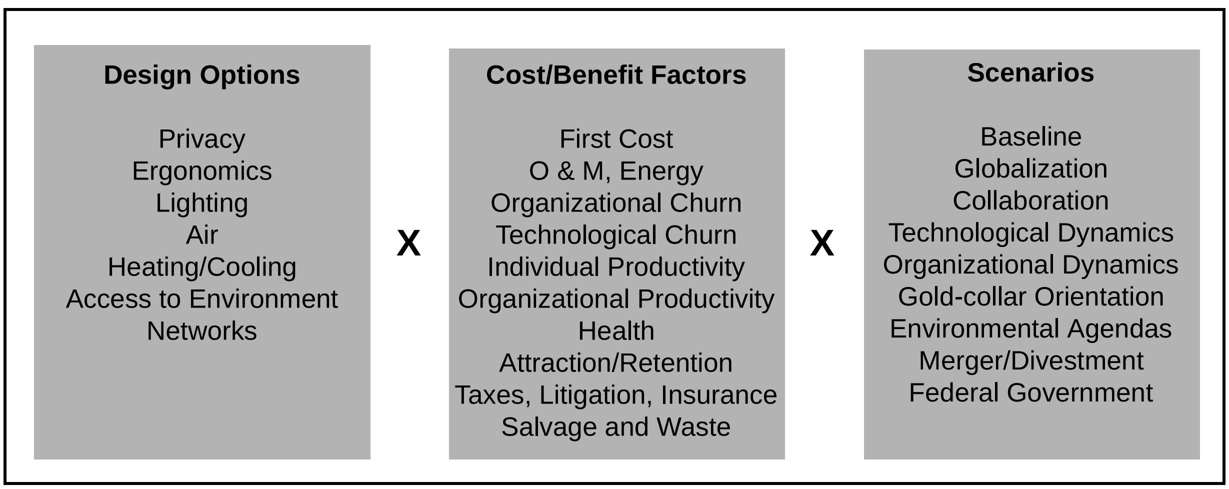


Figure 2. The three dimensions of the Intelligent Workplace EVA Matrix

1.3.1 Cost-benefit factors

First Cost Savings

- Integrated System Savings over Individual Components
- Quality and Modularity over Redundancy

There is substantial evidence that multi-disciplinary solutions may lead to greater building performance at equal or less cost. First cost savings have been shown to accrue through effective systems integration, including the merging of mechanical heating systems with facades, raised floors for networking with HVAC distribution, sunshading and orientation of facades with HVAC sizing and configuration. Although this first cost benefit is the easiest sell in the boardroom, it is the hardest sell to the professionals who must work together and maintain their confidence in integrated solutions in the face of litigation.

Another strategy for generating first cost savings with increased performance is replacing redundancy with accessibility when planning for change. Many building lighting and networking systems are designed with planned redundancy in the event of expansion. Thus 10-50% additional products are installed to support estimated long term demands, investments that often remain untapped due to the fixed nature of the redundant systems in the face of real organizational and technological changes. Reduced first cost investments in quantity of products can be traded for quality and reconfigurability of products.

Operational Cost Savings: Energy, Maintenance and Repair

- 1-2% of current plant value in energy
- 2-4% of current plant value in M&R

The second cost-benefit area is in operational cost savings, including energy, pollution mitigation, maintenance staffing and repair cost savings. Since energy costs are often well known by a building owner, substantial recommendations for innovation are often seriously considered if payback is less than 1-3 years. Beyond this time frame, however, few decision makers believe in the predictions of the cost energy, or that they will still own the building and still be accruing savings from the innovation.

Compared to energy savings, maintenance and repair cost savings are less successful promoters of "innovations for quality" because there are very incomplete records on causes of M&R costs, and what M&R savings (including manpower costs) would be offered by various design/engineering solutions. At present, HVAC operations and maintenance costs are presumed to be roughly 2-4% of current plant value.

Individual Productivity Cost Savings

- Speed, Accuracy, Effectiveness, Creativity, Impairment, Absenteeism

Since a majority of the annual employee and workplace costs is for salaries (over 60%), any innovation that will clearly increase productivity will pay back investments in quality products and systems. However, measuring productivity in the "gold collar" environment is difficult. Productivity must be studied independently for skill-based, rule-based and knowledge-based jobs, to include such variables as speed, accuracy, individual and collaborative effectiveness, and creativity. Two indices could be readily available to evaluate investments in quality buildings - self assessment of productivity and absenteeism. An additional indicator that could also be more readily explored than "output" is observed downtime for modifications, complaints, and interruptions.

Organizational Productivity Cost-Savings

- Time to Market, Profit, Company Value (present and future)

While individual productivity can be measured for some job descriptions, other knowledge-based jobs will have to evaluated through measures of organizational productivity. Time to bring product to market (design, engineer, manufacture), profit, as well as present and future stock value are all indices that can be used to cost-justify investments in quality built environments.

Health Cost Savings

- Insurance & Medical Costs, Health Litigation Costs, Workman's Compensation, Environmental Evaluation & Remediation

After salary, the second major annual cost of an employee is benefits, including medical and insurance costs as well as workman’s compensation. Again, measured reductions in these costs would justify investment in better quality environments. The most dramatic health-related costs are tied to "sick building syndrome" mitigation including health costs of employees, field study costs, litigation costs, remediation costs, and building down-time costs. Due to poor nation-wide records, the fact that the many serious down-time costs have occurred in new sealed buildings with all air systems still has not translated into reconsideration of design/engineering solutions or better first-cost investments in quality, accessible solutions with full commissioning.

Attraction/Retention Cost Savings

- Time and Quality Attracted, Training Costs, Retention Rates

Another aspect of the productivity cost-benefit equation is the ability to attract and keep the best workers, the time needed for training, and the commitment of those workers to unpaid overtime. Attracting and retaining the best employees can be linked to the quality of the benefits they receive, including the physical, environmental and technological workplace. Moreover, an estimated six months must be dedicated to training a new employee, such that rapid turnover (poor retention) should be considered as 6 months lost over the time spent with the company. In this way, poor retention can be translated into serious cost centers. In addition, the commitment of an employee to voluntary overtime and weekends, punctuality, and reduced break times could be linked to workplace qualities that support motivation rather than stress.

Renewability Cost Savings: Organizational Reconfigurability/ Churn

There are significant cost benefits to investing in renewable, quality building systems, if "churn" dollars could be considered. Significant additional expenses are presently incurred in buildings to support the:

- cost of reconfiguring working groups and individual space
- cost of accommodating changes in functions, densities, workhours
- cost of accommodating rapid changes in technologies
- cost of building system overload and failure

Some organizations have been working to reduce space reconfiguration costs through universal footprints, especially in back offices. On the other hand, other organizations are pursuing massive reconfigurations to support non-territorial offices, mobile workstations, micro workstations and teaming spaces in response to organizational re-engineering. At the same time, occupant density, length of workday, and technology have dramatically increased in the workplace. As a result, system overload and failure costs are now accruing beyond the already significant costs of conventional churn. The extent of these organizational churn costs are not well documented, nor the benefits of investing in quality, "renewable" solutions, resulting in a lack of support for better life-cycle decision making.

Renewability Cost Savings: Technological Reconfigurability/ Churn

- Network, Hardware, Software, Training, Management

The Forrester Group in Cambridge has found that Fortune 500 companies spend on average \$8,000 - \$10,000 per worker per year keeping desktop technology current. These costs are divided between hardware and software, networking, training and staffing. Over several years, these investments far outweigh the value of the physical workspace which contributes to the success or failure of computer based productivity. The \$1000 per worker per year in networking modifications alone would cost justify better tele-communications and power infrastructures. The ergonomic and environmental costs of a continuously evolving technological infrastructure must also be recorded for better life-cycle decision-making in relation to those infrastructures as well.

Tax/Code/Insurance/Litigation Cost Savings

- Tax Depreciation, Code Compliance, Insurance & Litigation Costs

A number of investments in quality building components and systems can be cost justified through cost-savings in taxes (rapid depreciation of movable infrastructures), code compliance (such as CFC, PCB and asbestos elimination), insurance savings (health, safety), and litigation cost savings (health, safety, waste). The building performance investments that can be achieved with savings in these cost centers have not been evaluated by most building owners and managers.

Salvage/Waste Cost Savings

- Organizational, Technological, Environmental Modifications

- Aging & Wear, Obsolescence, Salvage Value

Many buildings go through continuous cycles of spatial and technological change, often with major waste. Not only do workable infrastructures often have to be destroyed and rebuilt to allow for technological changes, but waste products can often be hazardous or bulky, and are requiring increasing expenditures for appropriate disposal. Moreover, the salvage value in these products (carpets, cabling, switches, pc's) is almost always lost. Greater investment in high performance products and systems might be fully justifiable in a short time frame if these waste costs/ salvage value are fully accounted for in the decision making process. Given long term goals to reduce national consumption of rare or non-renewable material resources, the implications of salvage and waste should be fully incorporated in building investment decision making.

Each of these ten cost-savings could fully justify better quality products and systems in very short time periods. The cumulative value of these seven cost centers over a 3-7 year time period could justify buildings of twice the initial investment with significantly longer design-engineering studies, typical of other industrialized nations. The resulting buildings also offer better organizational, environmental and technological quality for the end-user as well as being sounder solutions for a global environment.

1.3.2 Organizational Scenarios

The third axis of the matrix is the characteristics of organizational types that may effect the cost-benefit calculations for high performance products. The decision-maker is able to automatically modify the life cycle cost (LCC) variables by selecting a organization type, or individually modify the variables. The organizational types currently in BIDS are:

Globalization
The company goes multi-national, without HQ, through networked campus offices, main street offices, downtown offices and home offices, as well as offices in the manufacturing plant and maintenance and sales buildings.

Collaboration
The company fluctuates continuously between needing small, quiet, concentrated spaces and collective, noisy, team spaces with changing density and layouts of closed, open, shared, individual, central and distributed teaming.

Technological dynamics
The company changes equipment rapidly, shifting from one networked desktop unit to multiple, from shared inputters and outputters to one on every desk, from copper to fiber, from copper to wireless, from conference rooms with one port to 30 ports, ever increasing bandwidth and speed and hardware and software changes.

Organizational dynamics
The company changes organizational charts from pyramid and hierarchical to peer groups and lateral; from downsizing to rightsizing to upsizing; to split profit centers; to central research driven; to manufacturing driven; to advertising driven; to interactive; and all of the above.

Gold-collar orientation

The company has determined that people matter, the quality of their education, their experience, their commitment to the company, their ability to do individual and collaborative work; their health; their family's health; their community's health.

Environmental agenda

The company has determined that environment matters, that the resources consumed and the waste stream matter; that the quality of indoor and community environment matters; that they will be pivotal in demonstrating solutions for products and workplaces that are accessible world wide to an entire world population (including daylight, natural ventilation, pedestrian or public transportation).

Federal agenda

The Federal agency takes a long-term view of investments and values the greater public good rather than profits. The relationship of the agency to the local community and environmental resource issues are important to the organization.

The organizational scenario windows in BIDS allow the user to review the assumptions under each scenario and choose one that most closely matches her own. It is also possible to enter a customized set of values. The user interface features are described in more detail in Section 1.5.

Figure 3.

	Baseline	Globalization	Collaboration	Technological Dynamics	Organizational Dynamics	Gold-collar Orientation	Environmental Agenda	Merger/ Divestment	Federal Agency
Project size	100,000	75,000	100,000	100,000	100,000	100,000	50,000	100,000	100,000
Number of employees	500	375	500	500	500	500	250	500	500
Years of ownership/ lease (study period)	15	15	15	5	5	15	30	5	30
Discount rate	10%	12%	10%	12%	12%	12%	5%	15%	4%
Tax rate	33%	33%	33%	33%	33%	33%	33%	33%	0%
Churn rate	30%	30%	125%	100%	100%	30%	30%	100%	30%
Average salary per employee	$33,000	$60,000	$60,000	$75,000	$60,000	$100,000	$40,000	$75,000	$40,000
Average benefits per employee (25%)	$7,000	$15,000	$15,000	$18,750	$15,000	$25,000	$10,000	$18,750	$10,000
Electricity cost	$0.07	$0.10	$0.07	$0.07	$0.07	$0.07	$.12	$0.07	$0.07
Attraction/retention cost per employee (10%)	$3,300	$6,000	$6,000	$7,500	$6,000	$10,000	$4,000	$7,500	$4,000
Salvage cost									

Figure 1. Variable values used in the cost-benefit calculation for the z-axis organizational scenarios

1.4 Case Study Development 2000-2001

The CBPD continues to work on uncovering and developing building studies which in part or whole can add additional data sets to the EVA Matrix™. The CBPD has been selected by NIST/DOE as one of three institutions contributing to the development of a database of studies relating building technologies and the resulting indoor environmental quality to occupant satisfaction and productivity.

This is the third year of pursuing case studies, with a focus on air and thermal/ HVAC in the first year, lighting and access to the natural environment in the second year, and acoustics and ergonomics this year. Over 30 major journals and publications have been reviewed each year, with roughly 100 candidate papers assembled each year. The clear identification of cost-benefits as well as the clear delineation of physical parameters that have been varied has in each year reduced the number of viable case study descriptions to 20 per year. The BIDS tool presently has 69 case studies representing all 7 building performance goals and 8 of the 10 cost-benefit indices (not attraction/retention or salvage/ waste to date) (Table 1).

In attachment A are descriptions of the 24 new case studies identified for the Building Investment Decision Support Tool - 12 acoustics, 9 ergonomics and 3 air quality studies. Each case study has a header which indicates the building system action and cost-benefit recorded in the case study, followed by a brief description of the study, a summary of the assumptions in the financial calculations, and references. All of the calculations have adopted the OSHA formula for calculating labor savings or costs in relation to the percentage increase or decrease in productivity, as the costs of decreasing or increasing the workforce 1-/+(1/1+Prod). As the total number of studies increases, a number of common assumptions in relation to the calculations have been developing, which will be more fully documented in next years BIDS effort.

1.4.1 Literature Search and Review Process

The literature search focused on identifying publications and collecting articles linking acoustic quality and ergonomics to life cycle benefits. Numerous search engines and on-line library catalogs were used, in addition to searching professional and academic publications. The on-line documents as well as journals and conference publications identified are identified in Attachment B for both the acoustics and ergonomic summaries, including references that are still being collected.

The number of potentially relevant studies, articles or papers that were identified was over 250, with abstract reviews resulting in about 100 articles to be requested through inter-library loan, or downloaded/ purchased off the web. Once assembled, the articles were reviewed by the research team, graded as very relevant, moderately relevant, or minimally relevant. Over 30 very relevant studies were then carefully evaluated and summarized, with the resulting 24 new BIDS data sets in Attachment A.

1.4.2 Acoustic Searches and Results

Towards a better understanding of the cost-benefits of privacy and interaction, the CBPD team began a search on the relationship of acoustic environments to individual productivity and collaboration. From over 40 journals and conference proceedings, over 130 abstracts were reviewed, and 12 case studies from 7 articles were created. Adding the three previous studies, the BIDS tool now has 15 case studies that link acoustic conditions in the workplace to individual productivity (at both simple and complex tasks), with the dominant physical variables being sound absorption, sound masking, and quiet work environments/closed offices. No case studies were identified that linked variations in acoustic environments to collaboration, and no case studies were identified that linked acoustic environments to health, absenteeism, or other cost-benefit indices besides individual productivity.

Several conclusions can be drawn from these 15 data sets (see figure in Attachment A):

- Individual performance at simple tasks (for example, seven number sequence recall) is as much as 15% higher in sound masking environments than quiet environments, apparently due to “arousal” effect.
- Individual performance at complex tasks (for example mental math, paragraph completion, and memory) is 16-

40% higher in quiet environments than open offices without sound masking systems.

- Sound masking that is sculpted to the distracting speech (pink noise) can eliminate most of the performance degradation in open offices, however, individual performance at complex tasks is still 5% higher in quiet/ closed office environments than sound-masked open offices.

1.4.3 Ergonomic Searches and Results

The CBPD team began a search on the relationship of ergonomic attributes of the work environment to individual productivity and health. From over 80 web-sites, journals and conference proceedings, over 70 abstracts were reviewed, and 9 case studies from 8 articles were created. These nine case studies link ergonomic conditions in the workplace to individual productivity and musculo-skeletal disorders such as carpel tunnel syndrome, with the dominant physical variables being ergonomic chairs, keyboard supports and workstation configurations. Given these studies, the definition of ergonomic chairs, keyboards, and workstations (and ranges therein) will be more fully defined and included in the ABSIC guidelines.

Several conclusions can be drawn from these 9 data sets (see figures in Attachment A):

- The introduction of ergonomic furniture has reduced MSD claim costs by 43-82% in six case studies. MSD claims are typically only 1.64% (private companies) to 3.4% (public agencies) of all MSD symptoms, with average costs over $22,000 per claim. At this rate, the savings per worker from the introduction of ergonomic furniture ranges from $70-150 per worker per year.

- The introduction of ergonomic furniture is also linked to individual productivity in 8 of the 9 case studies, measured predominantly in typing speed and accuracy as well as editing speed and accuracy. The range of productivity increases from 5 to 23% appeared to relate directly to the level of ergonomic investment (as well as time at task) with the repositioning of monitors and provision of ergonomic chairs improving individual performance 5%, and the comprehensive provision of ergonomic chairs, articulated keyboards or adjustable workstations, and ergonomic training improving individual performance as much as 23%.

1.4.4 Interpretation of productivity data – time at various tasks.

The productivity indices in both of these sets of studies, as well as 3 additional studies identified relating to environmentally appropriate finishes and ventilation rates, challenged the CBPD team to identify the relevance of controlled experiment indices to today's professional work week. Many of the laboratory studies on "productivity" that have been identified for BIDS consistently select specific simple and complex tasks (such as number sequencing and memory recall) to ensure statistical significance, tasks that may only be a small subset of the workday. Consequently, the CBPD team has found a critical need to identify the range of tasks that US workers undertake in a typical workweek in order to interpret the results of controlled laboratory experiments.

Through the support of the GSA Productivity Protocol effort, the CBPD team has developed a simple questionnaire on "How do you spend your time?" to ascertain the relative distribution of tasks of white collar workers in various organizations (figure xxx). Within the next 6 months, an on-line version of this questionnaire will help ascertain the hours spent at various tasks, possibly by job description and industry, which will assist in the development of new criteria for controlled experiments and in the interpretation of the percentage impact on productivity from existing task-based laboratory studies.

1.4.5 Ongoing identification of new case studies

The CBPD is partnering in several national efforts to continue to identify and define productivity and energy data related to the built environment. The DOE/NIST effort with CMU, UCBerkeley and RPI has resulted in a new list of potential "productivity" papers from the international literature. CMU's partnership with DOE and RAND to develop the productivity workshop for the E- Vision conference in Washington DC in October 2000, resulted in. the commissioning of four overview papers on productivity research by William Fisk, David Wyon, Keith Lawton, and

Lisa Heshong These new papers (see references at the end of Attachment B) introduce several new productivity data sets that are being evaluated (3 already included in BIDS). The E-vision conference proceedings will include both the commissioned papers and a summary paper from the CBPD that emphasizes the importance of building research to the US economy and to decision making in the built environment (see new publications).

To contribute to the development of new ‘productivity” data from cross-sectional field studies, before and after studies, and simulation studies, the CBPD team has also been working with a federal research team led by GSA, with NAVFac, and NIH to begin the development of building evaluation protocols linking environmental, technical and spatial quality to individual and organizational effectiveness:

- Defining the distribution of work time/task central to productivity/performance studies
- Pinpointing Building Physical Attributes available and significant for federal studies
- Pinpointing Productivity/ Cost-benefit Measures available and significant for studies
- Identifying Scenarios/ Hypothesis for the development of productivity protocols

In order to identify the performance/financial data sets of real interest to the federal sector, the team defined five goals: 1. More effective organizational performance; 2. Greater collaboration or social integration; 3. More effective individual work;.4. Greater health of worker; 5. More effective resource use - energy and churn/materials

To date, the CBPD team has completed definitions of 20 research protocols for evaluating work environments and the prioritization of productivity research needs including a focus on measuring the effectiveness of collaboration, further developed the definition of churn for effective measurement in the field, and developed two on-line questionnaires for field evaluation. The CBPD has refined the building performance user questionnaire into an on-line evaluation tool and deployed the questionnaire in the before and after AWL studies. The ability to see statistical results on the fly is invaluable in drawing correlations with seasonal and organizational changes. The tool needs further development to draw statistically significant correlation’s between building attributes and user responses and across a broader set of buildings to provide data for BIDS.

1.5 User InterfaceDevelopment

Three major challenges were addressed by the research team in relation to the user interface. First, the limitations of the tool within Authorware which is not available on Internet Explorer, and could not be run on Mac computers was creating difficulties for a number of users. As a result, the decision was made to shift the tool and all of its calculations and data base onto an HTML platform. This internet accessible, HTML based tool has significant advantages in distribution, upgradability, and compatability for a wider audience.

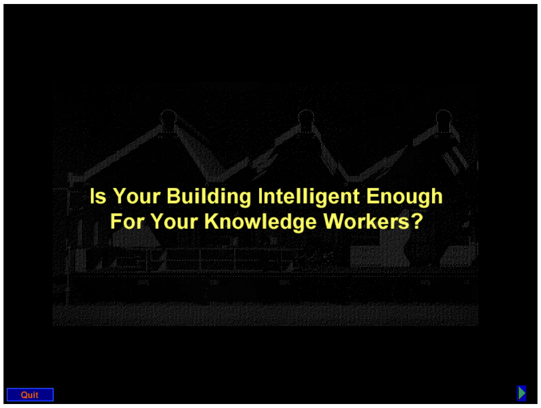
Second, the ABSIC users identified the need to allow user modification of the cost of building/component retrofit measures. The EVA Matrix™ in BIDS has always supported user modification of 10 characteristics of the organization: building square footage, employee numbers, average salary, average benefits, discount rate, investment period/years of ownership, electricity costs, churn rate, attraction/retention costs, tax rate. The BIDS tool has been modified to allow users to define their own project costs (100,000 square feet) or cost/employee for the retrofit action. Ultimately, the tool should request a time limitation or re-investment cost for each retrofit action, so that investments in components with a limited life will not yield benefits over longer years of ownership. While increasing the number of “hot” buttons the end user can modify, the CBPD team decided to support the user’s modification of the % of cost-benefit impact – the % of productivity, health, energy, or other index presently excerpted directly from the case study. This would allow the user to identify the sensitivity of the life cycle calculations to the % data in the case studies.

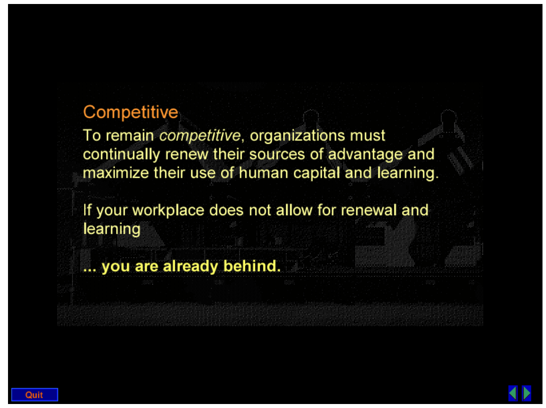
Third, the ABSIC users requested an interface that would support the parametric study of a data set given variations in the characteristics of the organization or costs of the retrofit. The BIDS tool now has an additional layer that enables the user to modify the list of assumptions that will affect the cost-benefit results of the case study and to table the comparisons for print-out. Ultimately, the tool should allow for graphic plots of the tabled data with appropriate captioning and references to support decisionmaking communications.

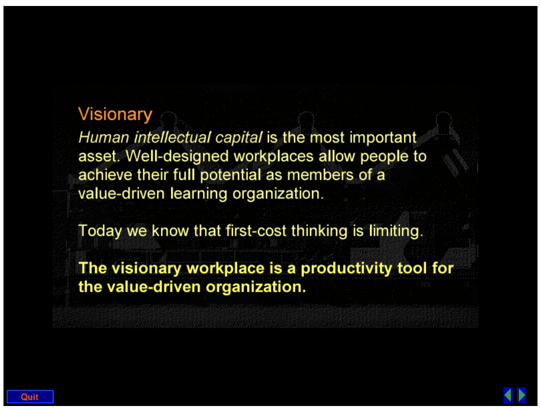
1.5.1 Features

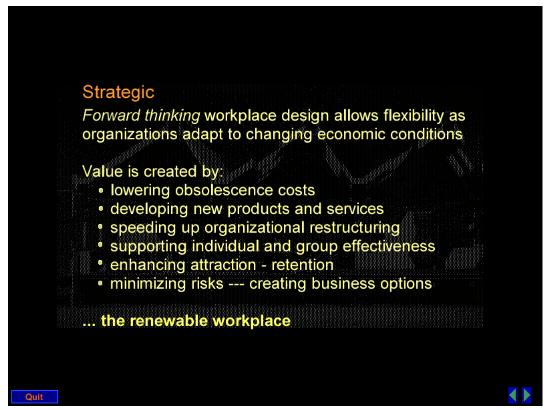
The BIDS tool V.3 beta is ready for release. The visual characteristics of the interface have been largely unchanged. However, the implementation platform has been upgraded to allow easier multi-platform access over the internet. The previous release in Macromedia's Authorware® required a vendor-specific internet browser plug-in. The new implementation has a database back–end, and uses active server pages (ASP) and hypertext markup language (HTML) script to generate the interface. The tool is accessible via an internet browser. An internet-accessible tool has advantages in distribution, upgradability, and compatibility, and allows access to the tool to a wider audience.

BIDS V.3 beta continues to allow a user to interactively enter values of variables which describe organizational characteristics. The tool will dynamically calculate the cost-benefit cells in the EVA® Matrix™. In addition, interactivity has been extended to include other variables and assumptions in the case studies. For each case study, the BIDS variables that are sensitive are exposed to change by the user. New functionality in the tool allows comparative sensitivity analyses to be run on any individual case. The results from multiple runs of a case where variable values have been changed are displayed together in tabular form on a page that is new to BIDS V.3 beta. The user can explore the effects that changing variable values have on the results as well as have a clear understanding of the variables that are sensitive in a case.









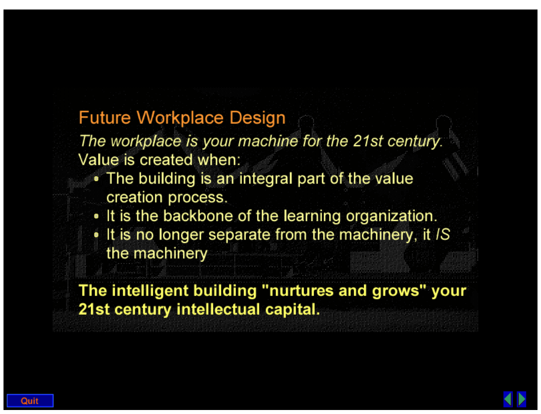
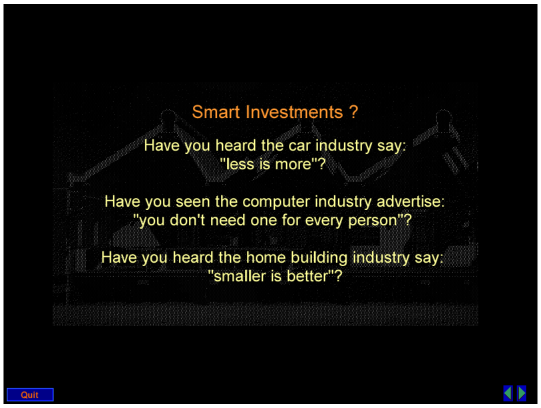
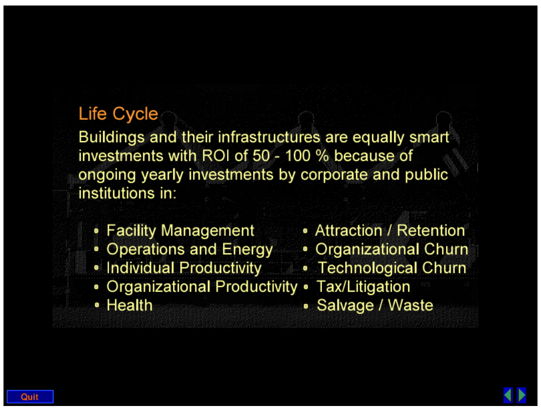
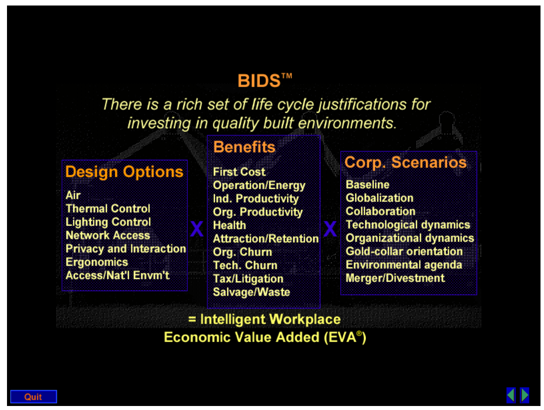


Figure 4. A series of slides exhibiting the introductory pages to BIDS and the IW EVA® Matrix. These slides explain the strategic importance of workplace quality for organizations to the financial decision maker at the CFO/CRE/Asset manager and facility manager level.







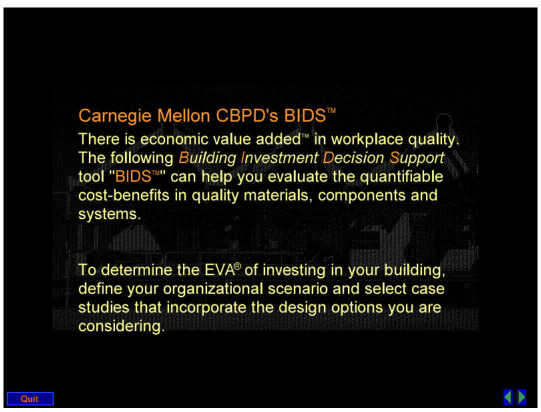


Figure 5. Introductory slides for BIDS and EVA® Matrix (Continued).

As described in the case development section, the case datasets in the "Lighting Control" and the "Access to the Natural Environment" design options have been substantially expanded. One of the resulting challenges is the modification of the interface to include numerous case studies. The goal is to enable the user to easily access the relevant case studies. The limitation of the screen space is a constraint, and the interface team has implemented a new option for case study navigation.

The literature bibliography is now active on the BIDS tool website, to enable the users to search and retrieve case studies of interest.

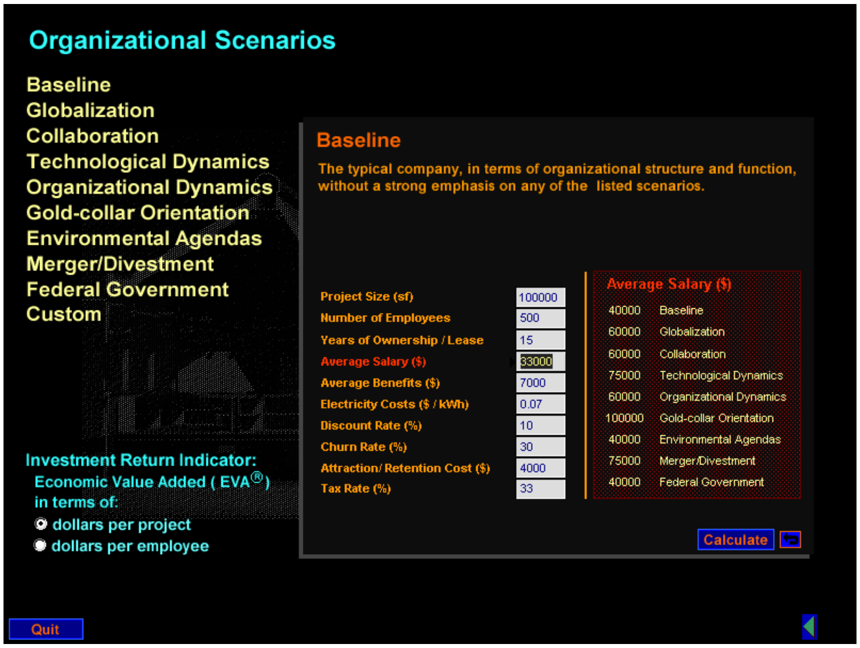


Figure 6. Snapshot of the Scenarios page showing the input window for the input of scenario assumptions.

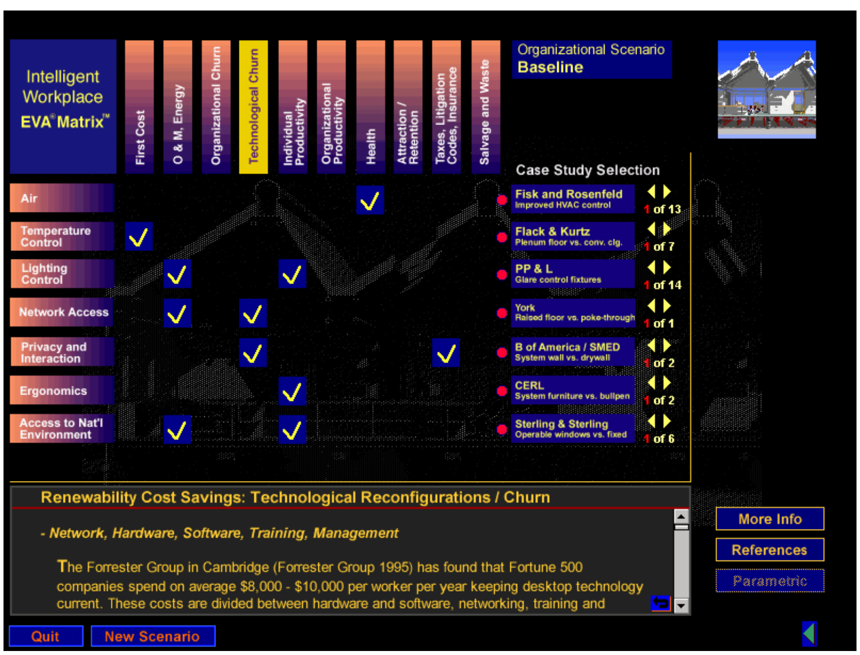


Figure 7. The case study scroll button on the right allows the user to navigate through multiple case studies. It also indicates the number of case studies currently available for each design option (e.g., 7 case studies currently included for the design option of Temperature Control).

Figure 8. Snapshot of the BIDS matrix showing the results of a case calculation.

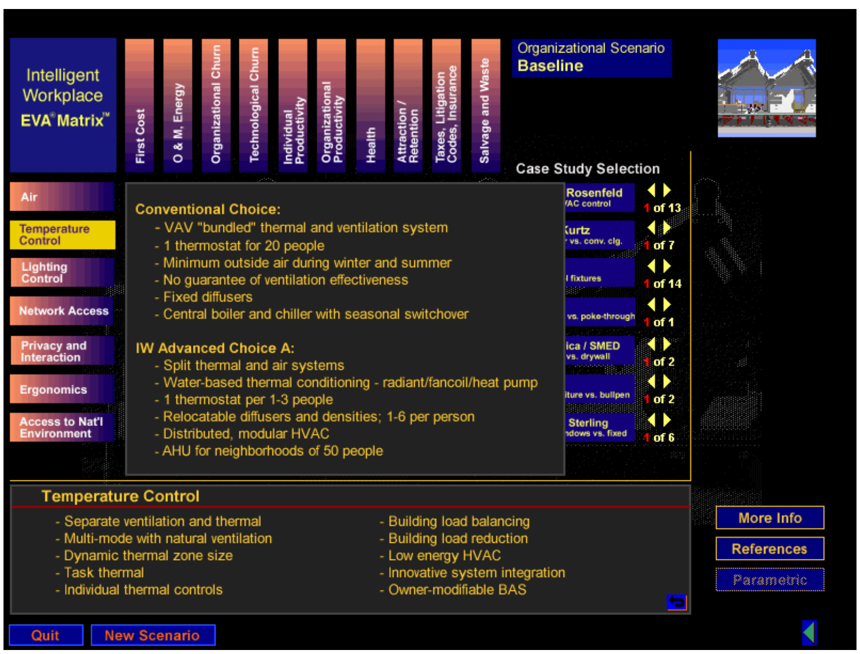


Figure 9. Snapshot of the BIDS matrix showing the description of the Temperature Control design option.

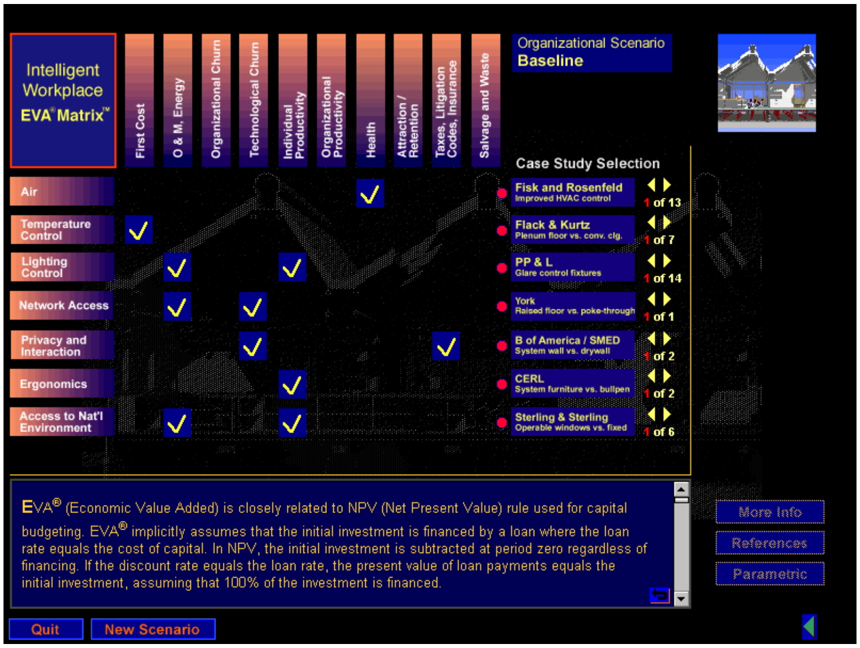


Figure 10. Snapshot of the BIDS matrix showing the window with the description of EVA®.

Figure 11. Snapshot of the BIDS matrix showing the description of the scenario assumptions.

1.6 Database Development

The previous version of the BIDS literature database was developed as a stand-alone application in Microsoft Access™. As a result, only one user could access the database at any one time and it required using the specific computer that stored the database. The new version is developed with a client/server architecture and can be accessed via the Internet through a web browser (http://gaudi.arc.cmu.edu/bids). This ensures that multiple users can access the database simultaneously from any computer that is connected to the Internet. The server is a Microsoft Personal Web Server™ and the script language is Active Server Pages. The new version has the following features:

- Easy maintenance and dynamic user query

  The database updates and user queries are independent of each other. Any updates can be viewed immediately and require no changes to the query codes for the user interface.

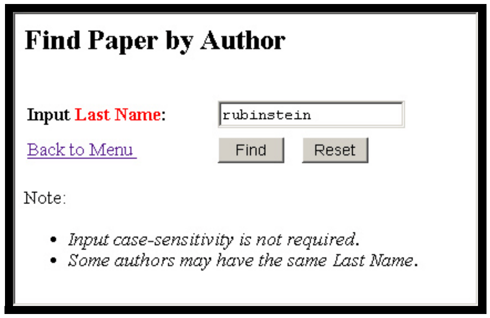
- Keywords combination query

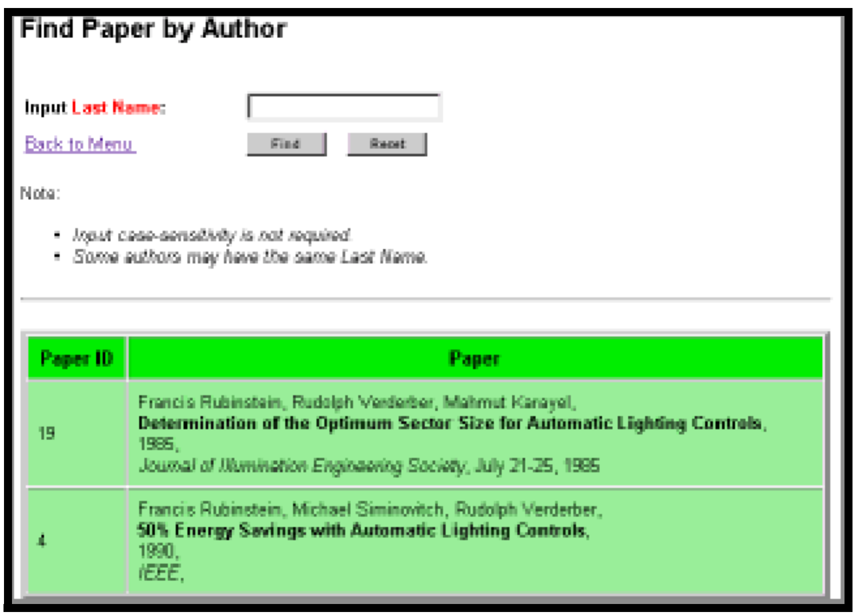
  A query that allows keyword combinations has been added. This query can be used to search for papers in the database using multiple keywords.

- Optimized database

  The relational database design implemented ensures that the information is stored efficiently and guarantees accurate query results.

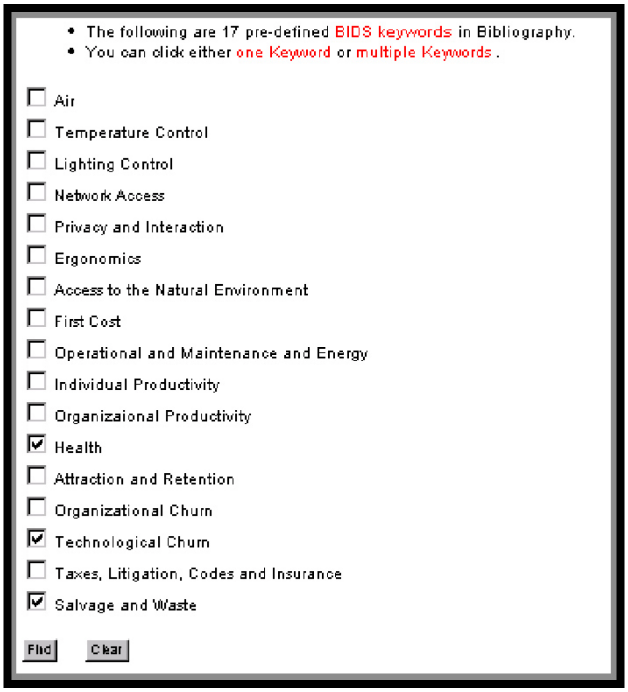
A series of snapshots of the interface showing the search capabilities and the typical search results are shown in Figures 12 to 14. Other new database interface features include additional predefined keywords. Online updates will be implemented in the future if the database security issues can be resolved.





Paper ID	Paper
19	Francis Rubinstein, Rudolph Verderber, Mahmut Karayel, **Determination of the Optimum Sector Size for Automatic Lighting Controls**, 1985, *Journal of Illumination Engineering Society*, July 21-25, 1985
4	Francis Rubinstein, Michael Siminovitch, Rudolph Verderber, **50% Energy Savings with Automatic Lighting Controls**, 1990, *IEEE*,

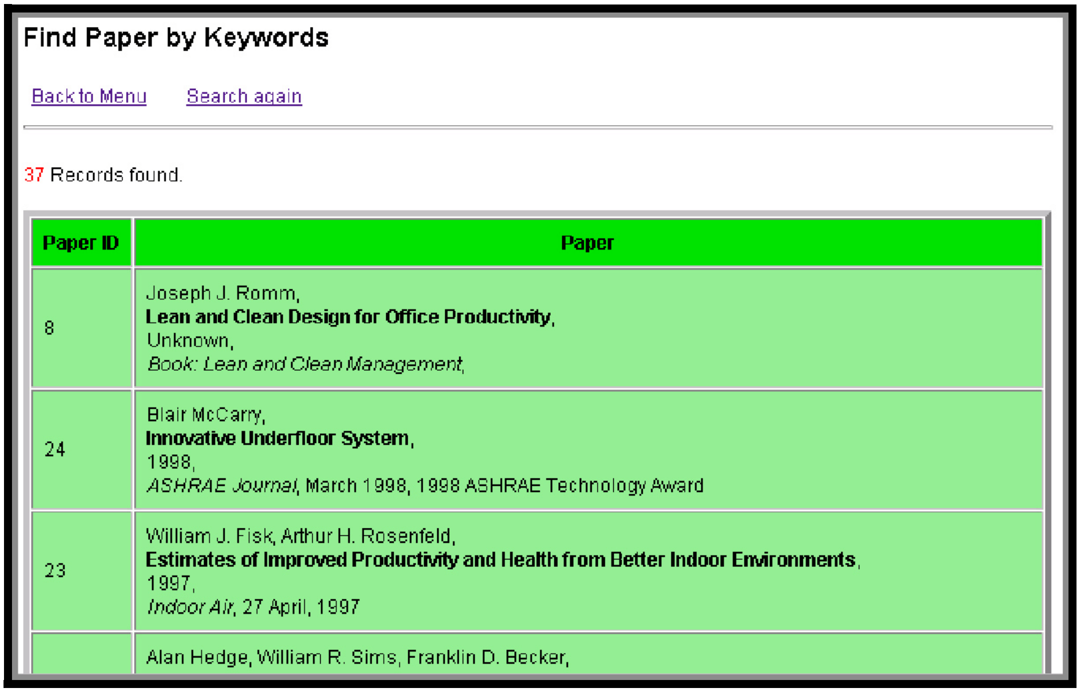
Figure 12. The "Find Paper by Author" entry box and result windows



- The following are 17 pre-defined BIDS keywords in Bibliography.
- You can click either one Keyword or multiple Keywords .

- [ ] Air
- [ ] Temperature Control
- [ ] Lighting Control
- [ ] Network Access
- [ ] Privacy and Interaction
- [ ] Ergonomics
- [ ] Access to the Natural Environment
- [ ] First Cost
- [ ] Operational and Maintenance and Energy
- [ ] Individual Productivity
- [ ] Organizaional Productivity
- [x] Health
- [ ] Attraction and Retention
- [ ] Organizational Churn
- [x] Technological Churn
- [ ] Taxes, Litigation, Codes and Insurance
- [x] Salvage and Waste

Find Clear



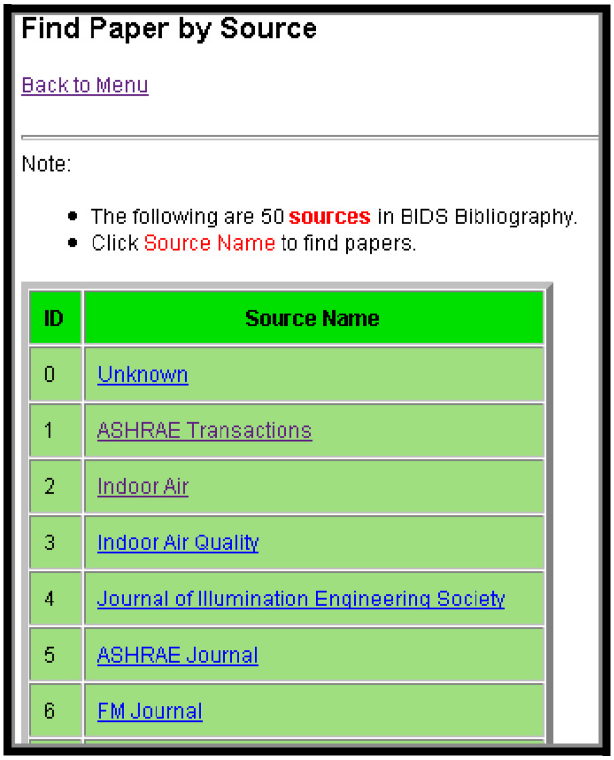
Find Paper by Keywords

Back to Menu Search again

37 Records found.

Paper ID	Paper
8	Joseph J. Romm, **Lean and Clean Design for Office Productivity**, Unknown, *Book: Lean and Clean Management*,
24	Blair McCarry, **Innovative Underfloor System**, 1998, *ASHRAE Journal*, March 1998, 1998 ASHRAE Technology Award
23	William J. Fisk, Arthur H. Rosenfeld, **Estimates of Improved Productivity and Health from Better Indoor Environments**, 1997, *Indoor Air*, 27 April, 1997
	Alan Hedge, William R. Sims, Franklin D. Becker,

Figure 13. The "Find Paper by Keywords" checkbox and result windows.



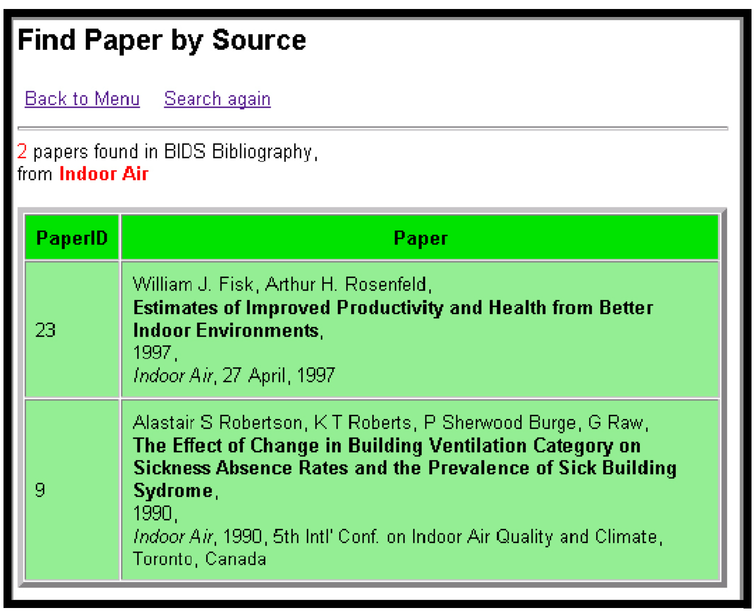


Figure 14. The "Find Paper by Source" entry box and result windows.

2.0 Major Research Accomplishments

The major research accomplishments for the 2000-2001 research period are:

- The development of economic language and logic geared toward the business investor.
  The development of economic language and logic whereby intelligent workplace design can be thought of by the business investor as analogous to other emerging, strategically-central, investments that have different operating life cycles (economic sustainability), competitive implications (workforce design), and payback periods (capital market valuation criteria).

- A framework for the evaluation of high performance building technologies (EVA® Matrix™).
  The development of a cost-benefit analysis framework for evaluating various advanced and innovative building system options in relation to a range of cost-benefit or productivity studies, to be incorporated within a multi-media decision tool.

- Development of a internet-accessible tool which implements the framework.
  The determination of cost centers where the benefits of high performance approaches will be significant, and the expansion of a data base relating quality indoor environments to major capital cost and benefit areas, including productivity, health, and operations costs.

- The addition of twenty-four new case studies in the Lighting Control, Access to the Natural Environment, Air, and Temperature Control design option areas.

- The refinement and addition of functionality to the user interface.

- The review of approximately 250 papers and their addition to the bibliography database.

- The refinement of the bibliography database user interface.

3.0 Next Steps/ Future Research

The BIDS tool has received widespread interest in presentations around the world, with requests for access and joint ventures for its development. We are confident that this tool will be a major catalyst for moving building decisionmakers to consider the life cycle value of building decisionmaking – and to invest in quality. The CBPD team feels that the best effort for 2001-2002, would be to work towards the web-based commercialization of the BIDS tool. The Dutch Government and Public Works Canada has expressed strong interest in partnering on this effort, as has InSite Real Estate Information Systems (Canada's largest corporate real estate information service). Two efforts at a minimum would need to be pursued:

- Web-based commercialization of the BIDS™ tool with legal ownership and clearances as an ABSIC reputation-building and income-generating tool (for its expansion and maintenance). Each of the 70 case studies would potentially need to be signed off by the original authors, and precise identification of the building retrofit actions and costs should be included (eg. What is an ergonomic chair).

- Develop case study input method for the solicitation of case studies worldwide simultaneous with on-line commercialization. Establish input form, necessary attachments, standard assumptions, finite list of methods used for calculating financial paybacks, "portal", and review process.

Alternatively, the research team could continue to enhance the tool through case study identification and generation, aiming for a later launch at 100 case studies. A number of tasks could be discussed for this research scenario for 2001-2002.

- Continue development of case study input, addressing networking life-cycle issues and pursuing energy data sets or health data sets that cut across all 7 guideline areas, yeilding 20-25 new data sets in a year.

- Develop new productivity data sets through cross-sectional field studies or before and after studies with outside funding.

- Develop groupings of data sets and cross-sectional understandings from the analysis of multiple data sets in relation to the 7 guideline areas (eg. Defining acoustic quality and the combination of simple, complex, and collaborative tasks in a typical work day).

- Identify relationship of actual distribution of tasks in a work-week and robust laboratory tests for evaluating the impact of the quality of the built environment on individual productivity, health, motivation..